Chapter 2
Tutorial: Contact EZMode™ Light Lever

BEFORE YOU BEGIN

This tutorial details the steps for taking a contact AFM image of the PNI AFM reference in EZMode™.

WARNING: Before operating the Nano-R™ AFM, make sure you are familiar with the safety information on page iv.

POWERING UP THE SYSTEM

1. Turn on the Master Computer.
2. Turn on the Controller.
3. Launch the SPM Cockpit software.
4. Turn on the video monitor.

SOFTWARE SETUP

1. Select Settings | Toolbar Mode | EZMode™.

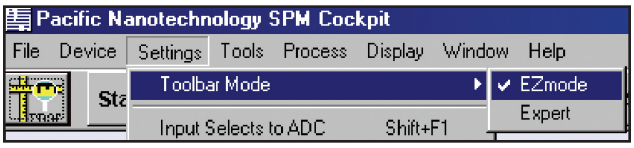


Figure 2.1: SPM Cockpit™

2. Click the Start button from the EZMode™ toolbar.

Figure 2.2: EZMode™ Toolbar

3. Click Retract Tip, and click OK when complete.

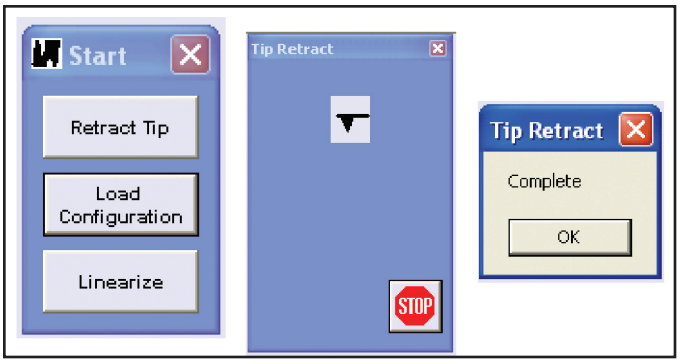


Figure 2.3: Retracting the Tip

4. Click Load Configuration, select the PNI-supplied contact mode configuration file, and click Open. This file should be located in the ConfigFiles folder in the SPM Cockpit™ directory. It has the format xxxxcontact.LLcfg, where xxxx is the serial number of your Light Lever Nano-R™ system.

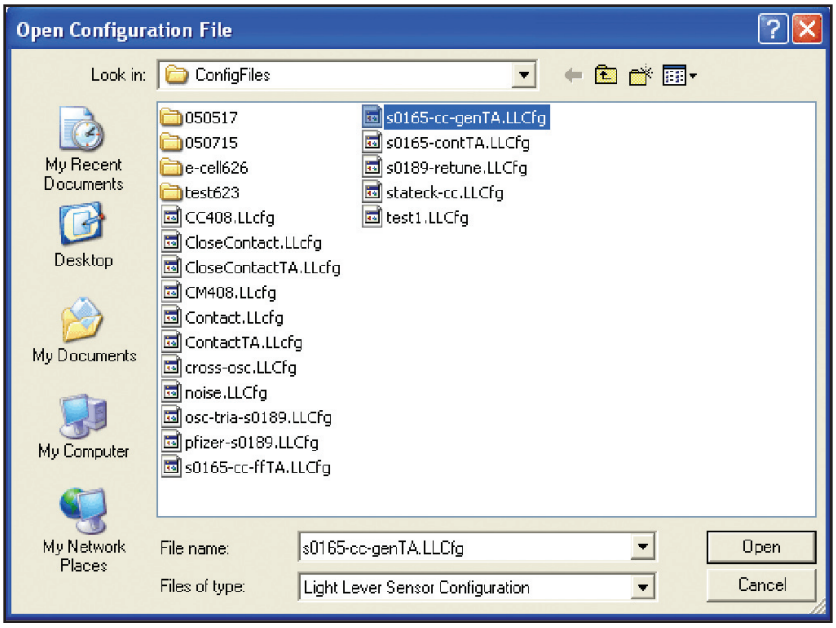


Figure 2.4: Loading a Configuration File

5. Click Linearize, check both boxes, and click OK.

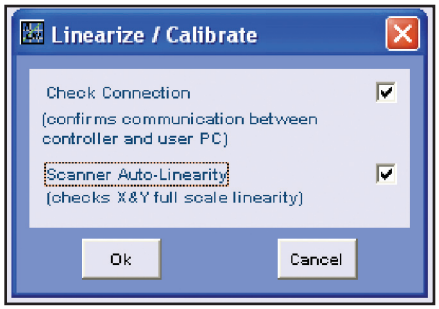


Figure 2.5: Initiate Connection Confirm and Calibration Routines

6. Click OK when the communication between the Master Computer and the Controller is confirmed. If there is no connection, you need to exit the SPM Cockpit software and restart both the Master Computer and the Controller.

Figure 2.6: Connection Confirmed

7. Click Start to proceed with the linearization procedure.

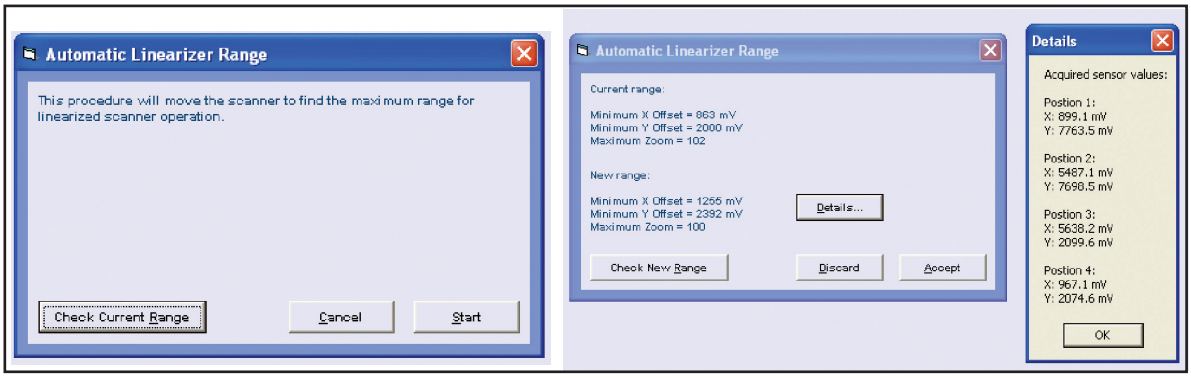


Figure 2.7: Automatic Linearizer Range

8. Click Accept when the calibration process is complete, and then click Check New Range if desired. Sensor readings will be recorded while the scanner is moved. Straight diagonal lines in both graphs indicate a good range.

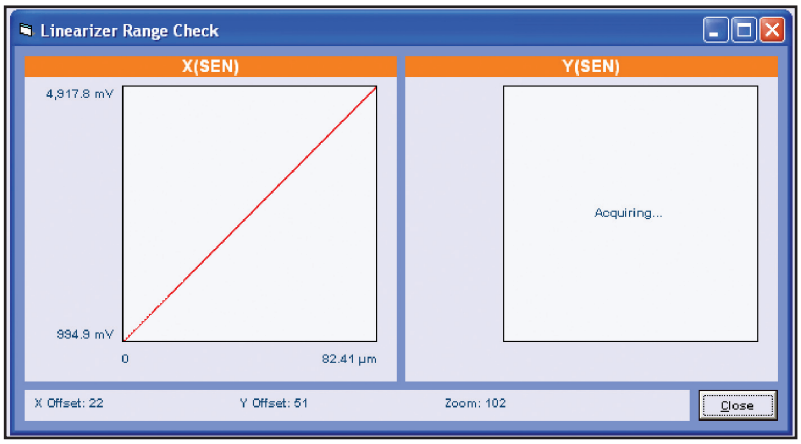


Figure 2.8: Checking Linear Range

9. Click Select Mode on the toolbar, select Contact in the dialog, and click OK.

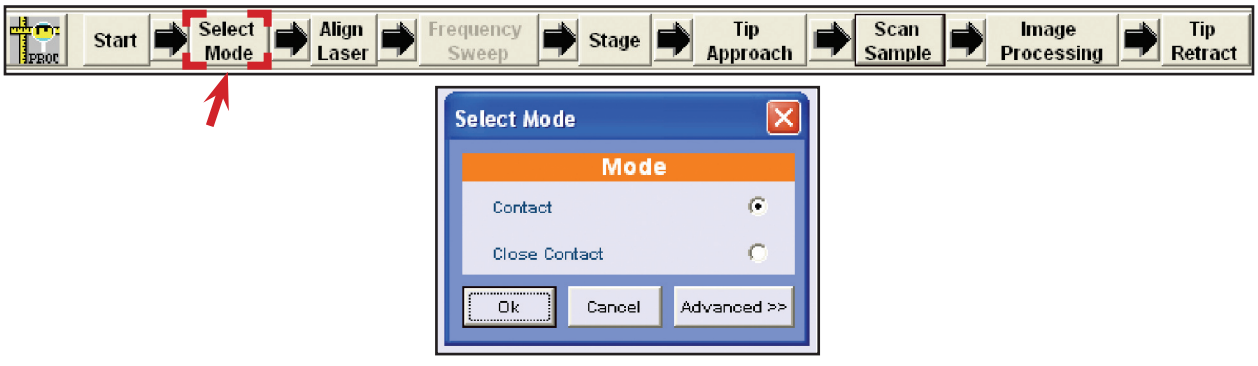


Figure 2.9: Select Mode

ALIGN THE DETECTOR

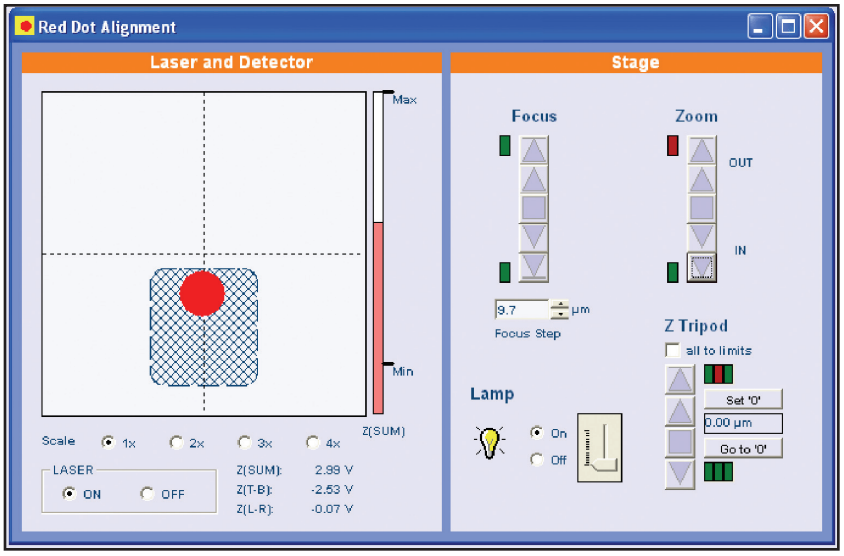


Figure 2.10: Red Dot Window Controls

If you cannot find the probe on the monitor:

- The probe may not have been installed properly. Repeat the probe screws installation procedure to make sure the probe is seated squarely in the "L" mount.
- The objective's field of view may need to be adjusted in X-Y, using the adjust screws. This is usually necessary when switching between a contact and close-contact probe, due to the difference in size. You can confirm that you have installed a contact cantilever by noting the difference in length between contact and close-contact cantilevers, as shown in Figure 2.12.

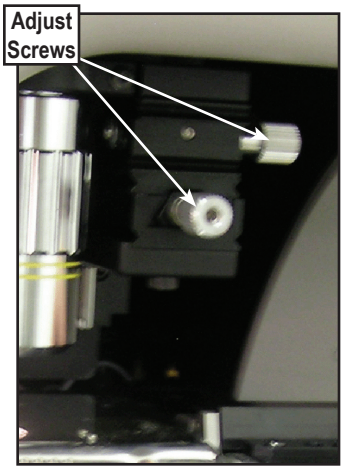


Figure 2.11: Probe Installation

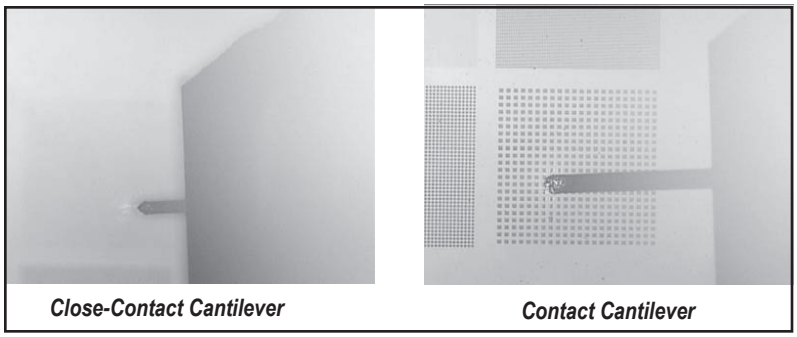


Figure 2.12: Contact vs. Close-Contact Probes

The red dot alignment procedure has 3 goals:

- position the laser spot on the back of the cantilever
- position the photodetector in the center of the reflected laser beam
- achieve a maximum minimum overall measured signal strength

Watch the video monitor as you adjust the laser alignment knobs on the scanner head to bring the laser spot onto the back of the cantilever. The laser spot should be centered on the cantilever, not too close to the end, as shown in Figure 2.13.

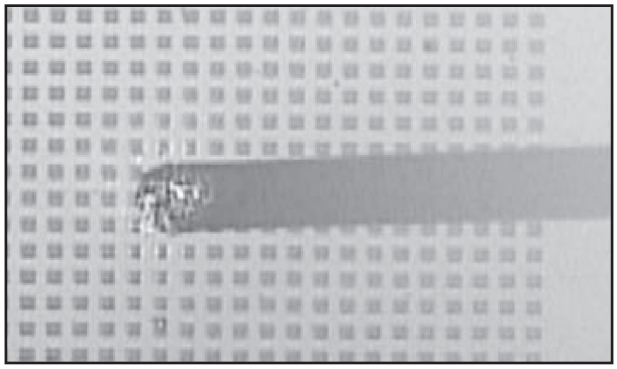


Figure 2.13: Centering the Laser Spot on the Cantilever

Watch the red dot (in the Red Dot Alignment window shown in Figure 2.14) as you turn the detector alignment knobs to bring the red dot into the top of the green crosshatched box. The red dot should be positioned just below the upper border of the box and be centered along the vertical axis. Please Note: If – when adjusting the detector alignment knobs – the red dot moves toward the center but the Z(SUM) value is going down, you are moving in the wrong direction.

Make sure the Z(SUM) value (signal intensity) is above the minimum. If it is not, you need to re-seat or replace the probe.

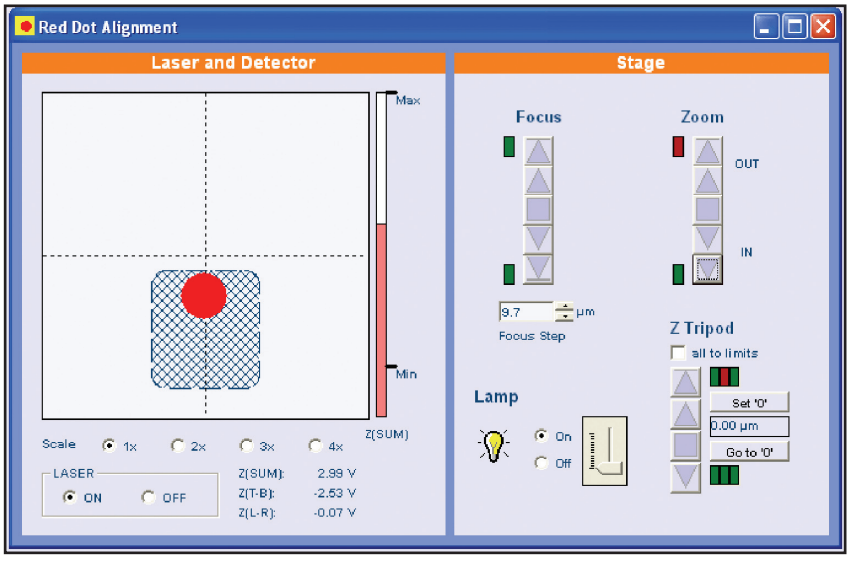


Figure 2.14: Aligning the Detector

LOAD A SAMPLE

- Click Stage from the EZMode toolbar.

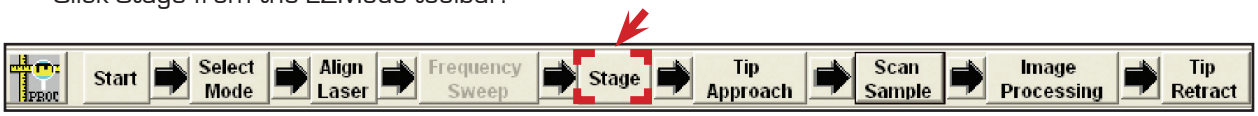


Figure 2.15: EZMode™ Toolbar

CAUTION: Whenever you engage the motorized X-Y stage, be sure the probe is a safe distance above the sample puck.

- Use the focus controls to bring the sample surface into focus on the video monitor.
- Use the X-Y stage controls to navigate to the largest of the four patterns on the PNI AFM reference (10 µm squares/20 µm pitch).
- Before approaching the same you need load the sample and locate the features of the interest to image with AFM
- Click the Up button to raise the Z motor until there is at least a few millimeters of clearance between the probe and the sample surface or puck, if no sample is loaded (monitor by eye).

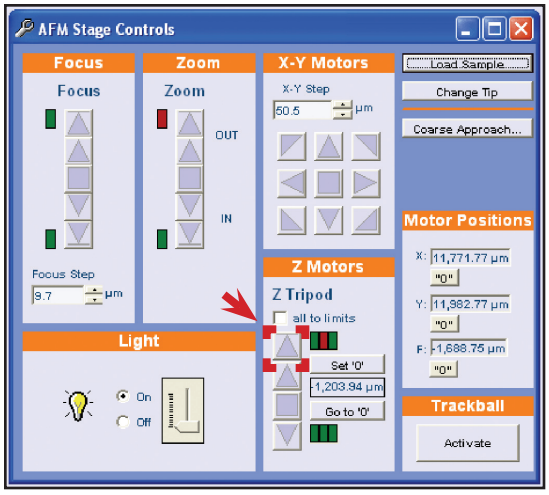


Figure 2.16: Raise the Probe Tip away from the Sample

CAUTION: To prevent damage to your scanner, probe, and sample, be sure you have retracted the tip and raised the Z scanner (as described in the preceding steps) before moving the puck.

- Click Load sample and then Start button. The motorized X-Y stage will move the puck towards you, to the limit of its range.

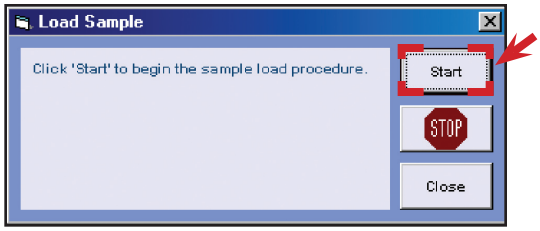


Figure 2.17: Load Sample

Being careful not to touch the probe, slide the sample puck towards you, and then lift it up out of the groove. (Figure 2.18)

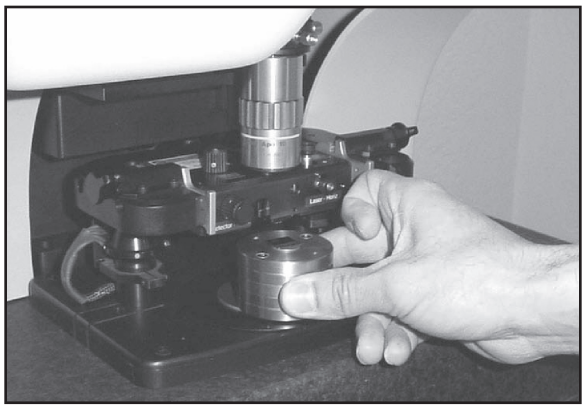


Figure 2.18: Remove Puck

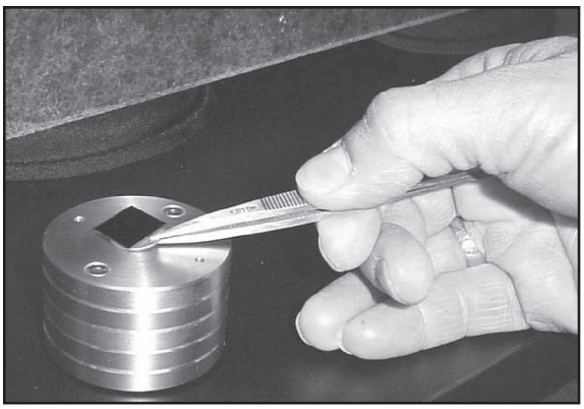


Figure 2.19: Mounting the Sample

Use tweezers to mount the PNI AFM reference on the center of the puck. The sample disk is held in place magnetically. (Figure 2.19)

Replace the puck on the stage by setting it down so the protruding piece on the bottom fits into the wide part of the groove, and then slide it into position. Rotate the puck so that the PNI reference sample is square with the scanner head. (Figure 2.20)

Figure 2.20: Fit the Sample Puck into the groove on the X-Y Stage

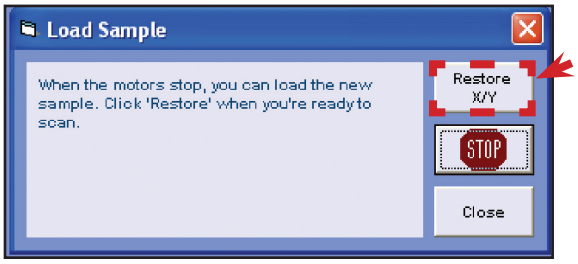


Figure 2.21: Return Sample Puck to initial X-Y Position

Click RestoreX/Y button on Load sample window. The motorized X-Y stage will return the puck to its original position. (Figure 2.21)

CHANGE A PROBE

To operate in contact mode, you need to use a contact probe. Probes should be stored in the supplied boxes marked “Contact” and “Close-contact,” as the difference between the two types of probes is not easily visible to the naked eye.

- First, remove the sample puck as described in the section above.
- Click Stage from the EZMode toolbar, and click Change Tip in the AFM Stage Controls dialog.

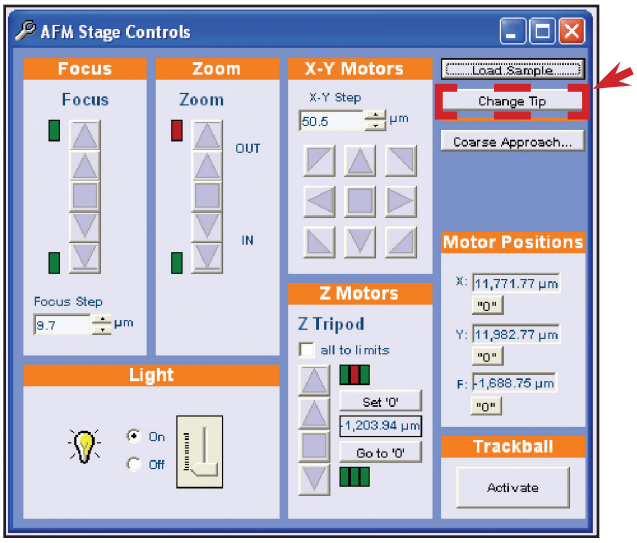


Figure 2.22: Change Tip will put the scanner head into appropriate position to replace the tip.

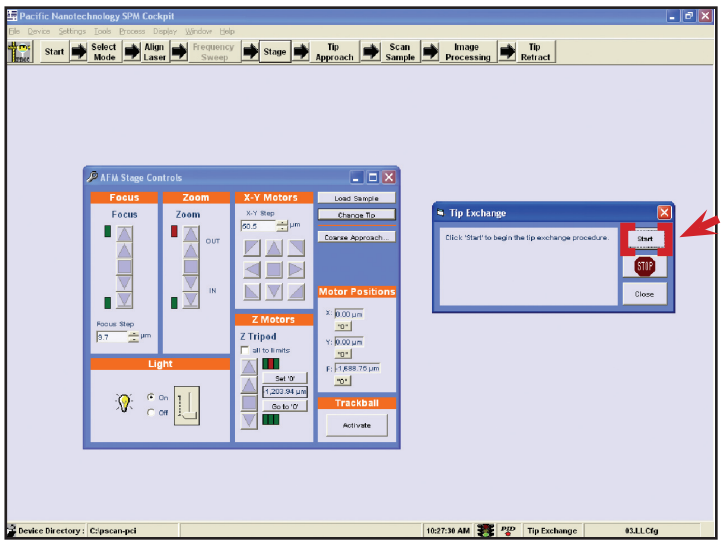


Figure 2.23: Start Button will raise the probe tip away from the Sample

Turn the probe exchange knobs on the side of the scanner head down (away from you) 1/4 turn (Figure 2.24). The scanner head will slide out about an inch.

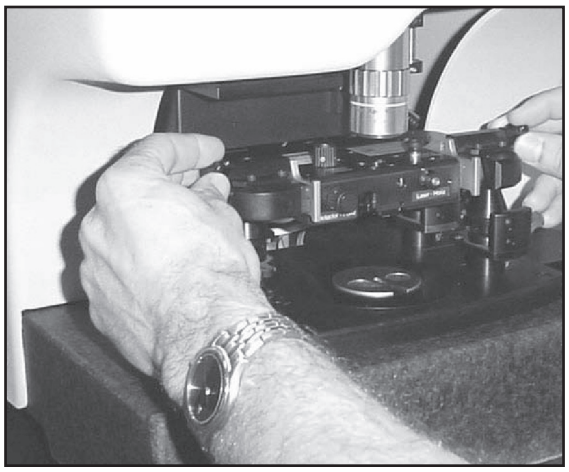


Figure 2.24: Turn the knobs to disengage the scanner head

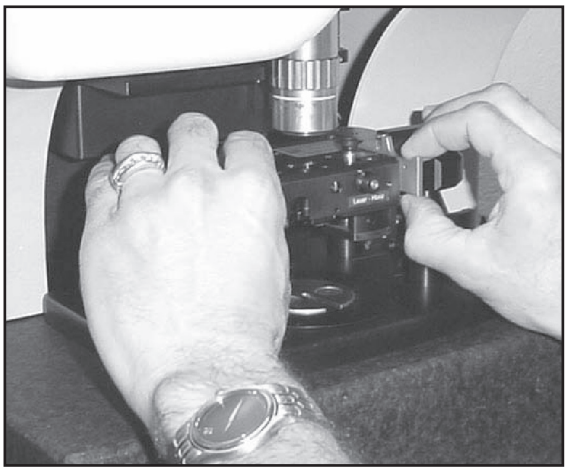


Figure 2.25: Slide the scanner head toward you

Grasp the handles on the front of the scanner head (Figure 2.25), and gently slide the scanner head all the way towards you

Carefully rotate the scanner head up about 90 degrees, as shown in Figure 2.26.

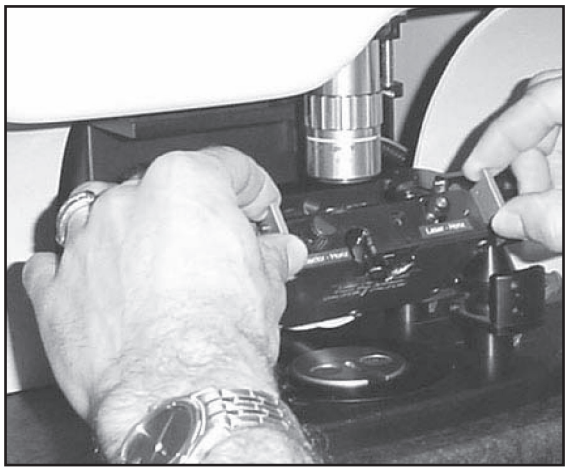


Figure 2.26: Rotate the Scanner Head

CAUTION: Handle AFM probes with care. The cantilever can break off easily if it touches anything or snaps down too forcefully on the magnetic mounting surface on either the scanner or in the probe box.

Probe handling: When loading or removing a probe, pivot the substrate on the edge opposite the cantilever, as shown below. This will protect the cantilever from striking the magnetic mounting surface, and it will prevent the substrate from snapping down too forcefully, which may damage the probe.

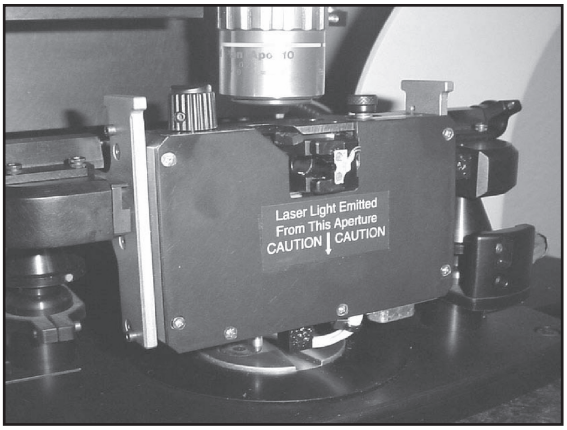


Figure 2.27: Probe Exchange Position

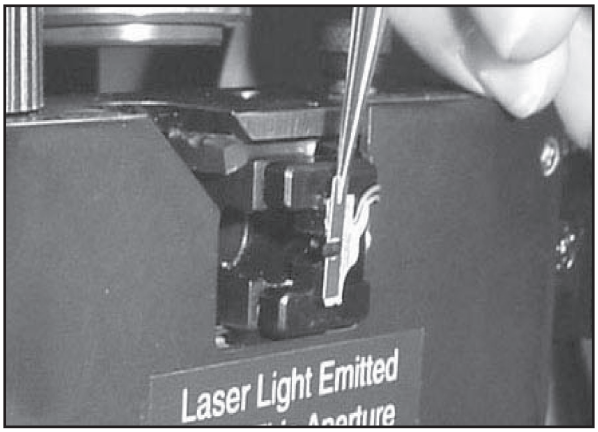


Figure 2.28: Mounted Probe

To remove a probe:

- Use tweezers to grasp the metal substrate as indicated in Figure 2.28.
- Carefully rotate the tweezers so the cantilever side of the substrate lifts up off the magnetic mount first.
- Set the probe down onto the magnetic strip in the probe box so that the side of the substrate opposite the cantilever makes contact first.
- Carefully rotate the tweezers so the cantilever side of the substrate comes down onto the magnetic surface as gently as possible.

To install a new probe:

- Use tweezers to nudge a probe so that the substrate extends over the edge of the magnetic strip in the probe box (Figure 2.29).

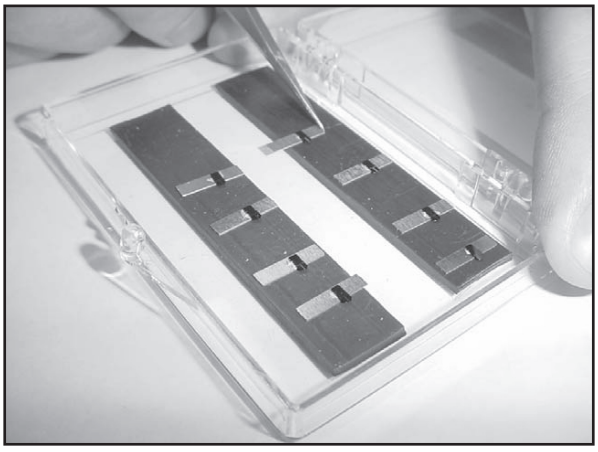


Figure 2.29: Nudge the Probe into Position

- Grasp the metal substrate, and carefully rotate the tweezers so the cantilever side of the substrate lifts up off the magnetic strip first as shown in Figure 2.30.
- Place the probe onto the magnetic mount so the side of the substrate opposite the cantilever fits into the “L”.

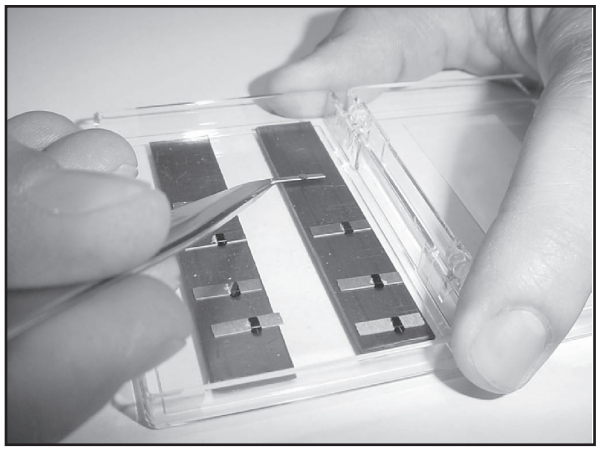


Figure 2.30: Lift the Probe, Cantilever side first

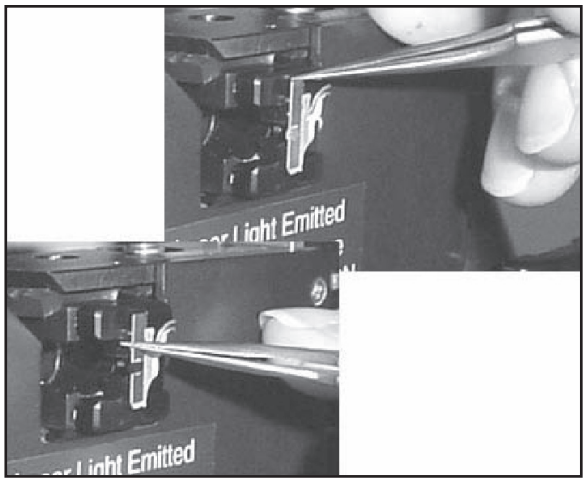


Figure 2.31: Push the probe substrate flush against the “L” mount

- Use tweezers to push the substrate flush against the “L” as shown in Figure 2.31.
- Hold the scanner head by the handles and rotate it back to the level position.
- Gently slide the scanner back towards the stage until you feel some resistance.
- Turn the probe exchange knobs up 1/4 turn to lock the scanner head into place.

Now you can replace the Sample Puck, as described on page 14. Once the probe is replaced, click the Restore button. It will restore Focus and Z-motor positions to their initial settings.

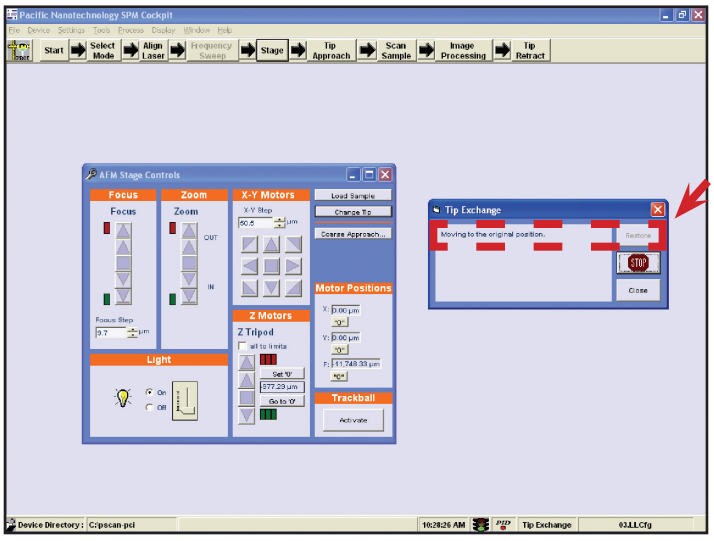


Figure 2.32: SPM Cockpit

COARSE APPROACH (Optical Assistance)

Coarse approach is very helpful to bring the probe into close proximity of the sample surface.

- Click Coarse Approach on Stage Control Window

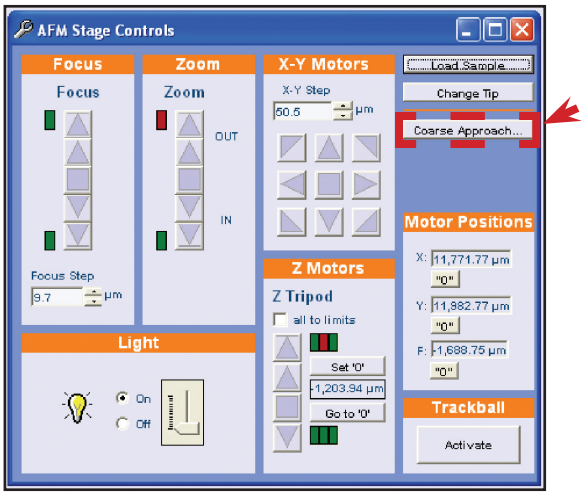
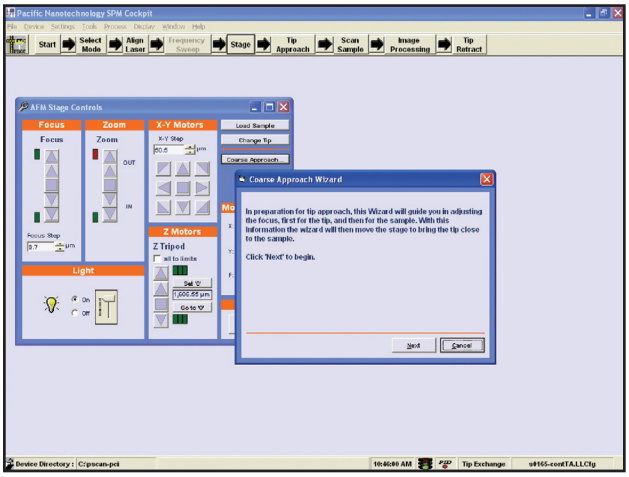


Figure 2.33: Stage Controls



- Click Next on Coarse Approach Wizard and follow instructions as shown below.

Figure 2.34: Coarse Approach Wizard

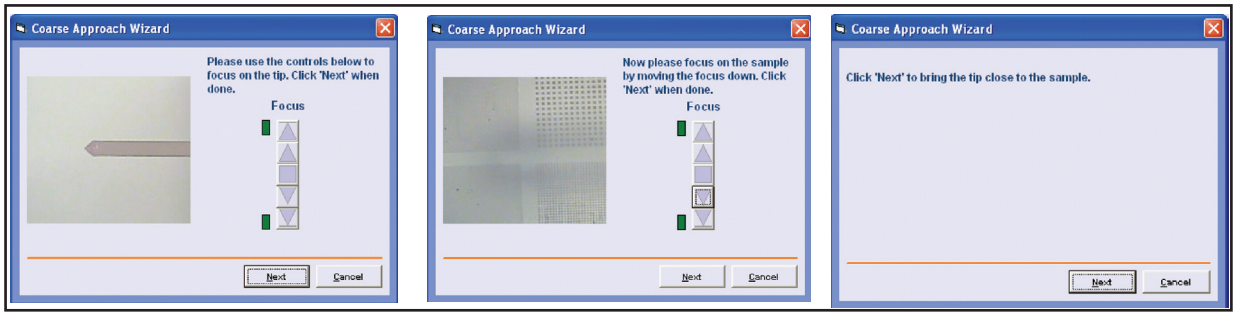

Coarse Approach Wizard
Please use the controls below to focus on the tip. Click 'Next' when done.
Focus
Next
Cancel
Coarse Approach Wizard
Now please focus on the sample by moving the focus down. Click 'Next' when done.
Focus
Next
Cancel
Coarse Approach Wizard
Click 'Next' to bring the tip close to the sample.
Next
Cancel

Figure 2.35: Coarse Approach Wizard Screens

First, focus on Probe, then focus on Sample and click Next.

Locating Features of the Interest

After Coarse Approach, Features of the Interest can be located by using the X-Y steps, to facilitate both coarse and fine movements.

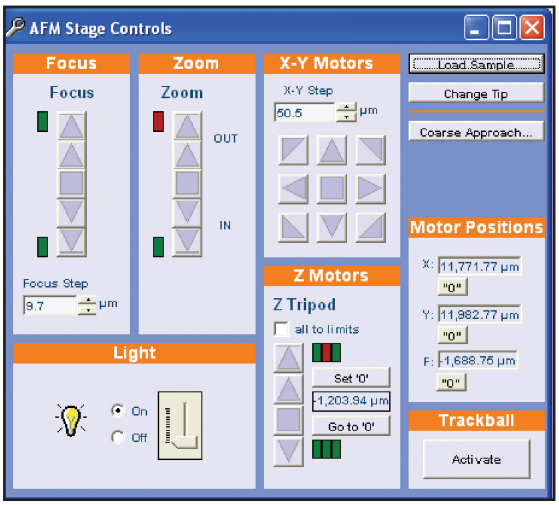


Figure 2.36: X-Y Stage Controls

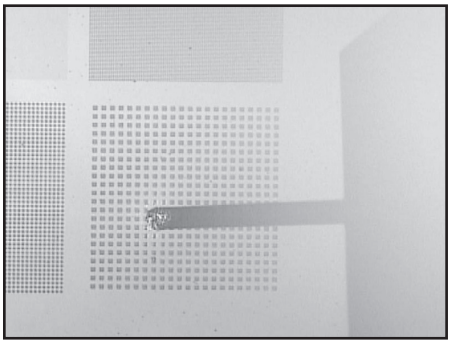


Figure 2.37: Positioning the Probe over the Scan Area (10µm squares / 20µm pitch)

If necessary, you can orient the Sample by simply rotating the Puck by hand. Focus on the Cantilever. Click Tip Approach button.

Figure 2.38: EZMode™ Toolbar

CAUTION: Once the Tip Approach is complete, and the tip is in contact with the sample surface, do not exit the SPM Cockpit™ software or turn off the Controller without first retracting the tip. Doing so may cause damage to the tip, scanner, and sample.

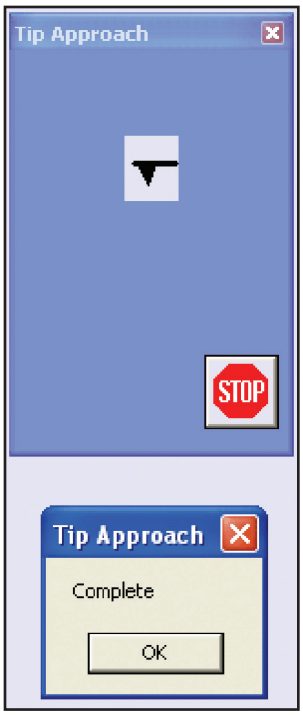


Figure 2.39: Tip Approach

The PID indicator at the bottom of the window will turn green to indicate that the probe tip is in contact with the sample surface, and the instrument is now ready to perform a scan.

SCAN THE SAMPLE

- Click the Scan Sample button on the toolbar

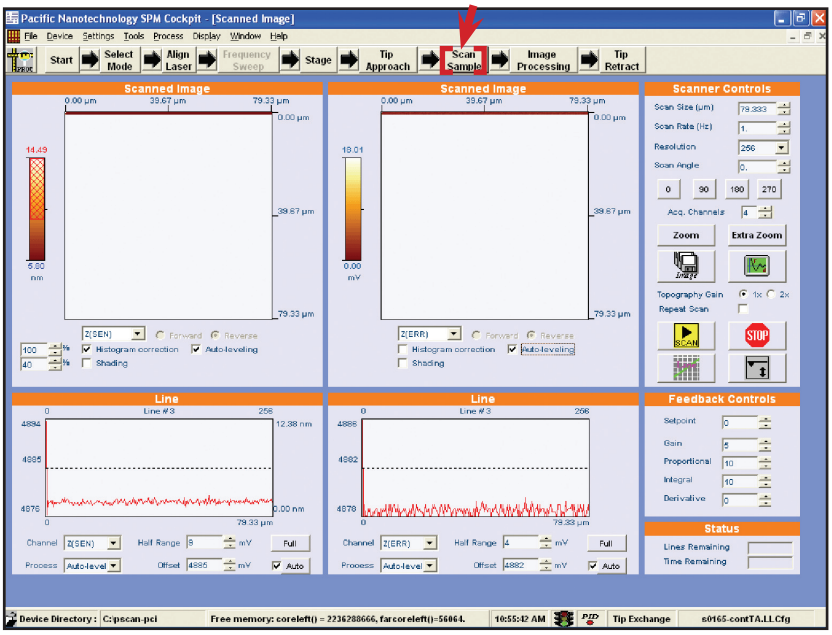


Figure 2.40: Scan Image Window

- Set the scanner controls as follows:
  - Scan Size: Leave as is – the default size, which is entered by the system when the calibration routine is performed, is the maximum scan area for our scanner.
  - Scan Range: 1 Hz
  - Resolution: 256
  - Scan Angle: 0
  - Acq. Channels: 4
  - Topography Gain: 1x

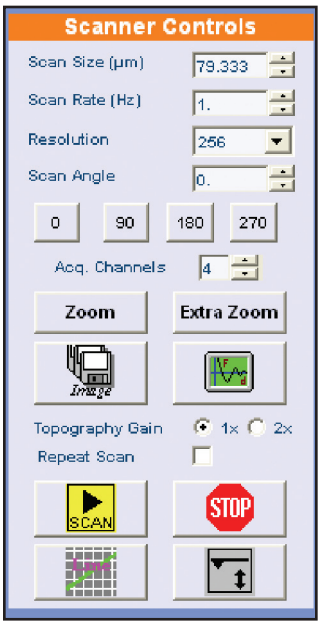


Figure 2.41: Scanner Controls

- Set the feedback controls as follows:
  - Setpoint: 0
  - Gain: 2
  - Proportional: 5
  - Integral: 5
  - Derivative: 0

Figure 2.42: Feedback Controls

Select the Z(SEN) and Z(ERR) channels from the drop-down menus beneath the two image displays, and for each display, select Forward, Histogram Correction, and Auto-Leveling.

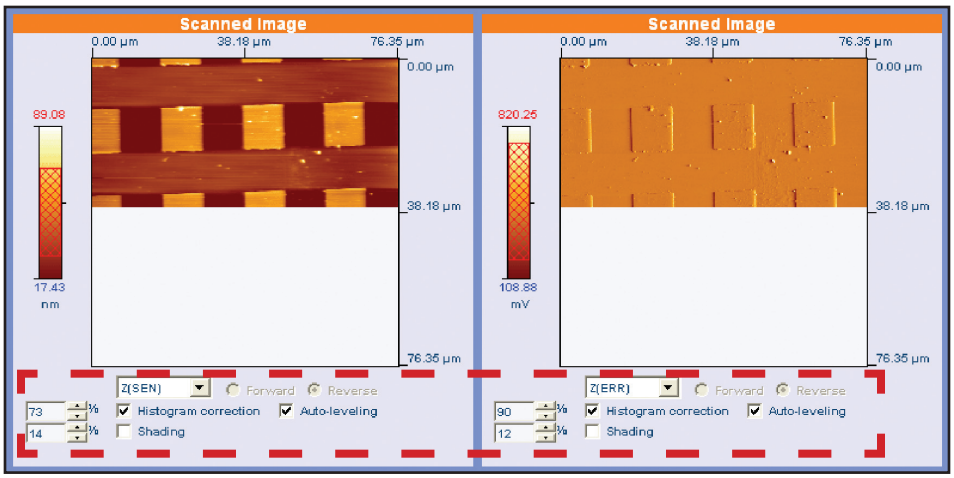


Figure 2.43: Image Display Settings

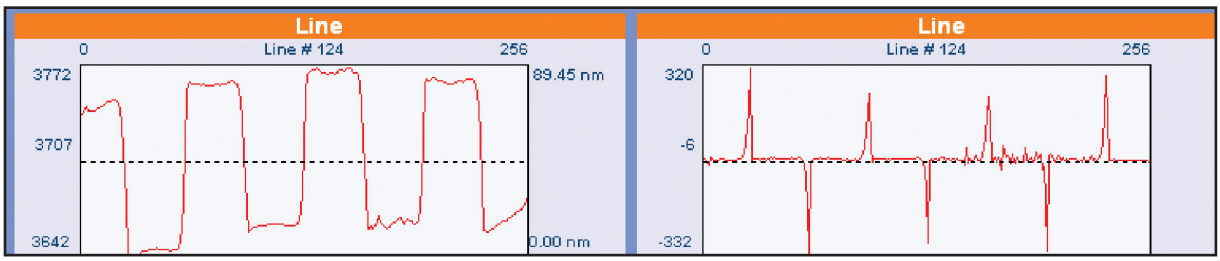


Figure 2.44: Line Scan Settings

- Select the Z(SEN) and Z(ERR) channels from the drop-down menus of the two corresponding line scan displays.

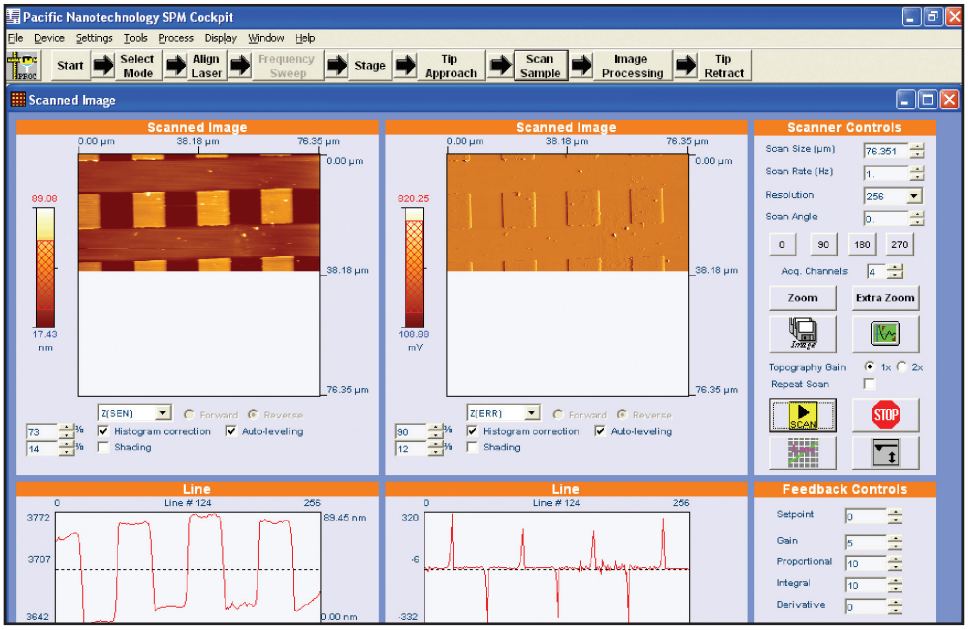


Figure 2.45: Taking a Scan

- Click Scan button to take a scan

  - The images of the selected channels will build up line-by-line in the displays. If no data is generated, the detector may be out of alignment. In this case, click Tip. Retract from the toolbar, re-align the red dot (Page 12), and try another scan.

  - To adjust the Z scale of the images, left-click and drag the bar to the left of each display to select a Z height range.

  - To view a single line scan, hold down the SHIFT key and left click in either image display to define a horizontal line across the image. Make sure the line includes the square features. The line scan profile for the Z(SEN) channel should resemble the shape and size of the 10∝m features.

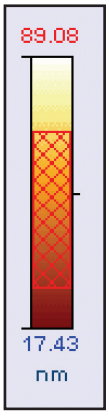


Figure 2.46: Scale Adjust

- To take additional scans, click Scan again, or check Repeat Scan to take continuous scans of the same region.

- To zoom to a new scan region:

  - Left-click and drag in the image display to define a scan area.

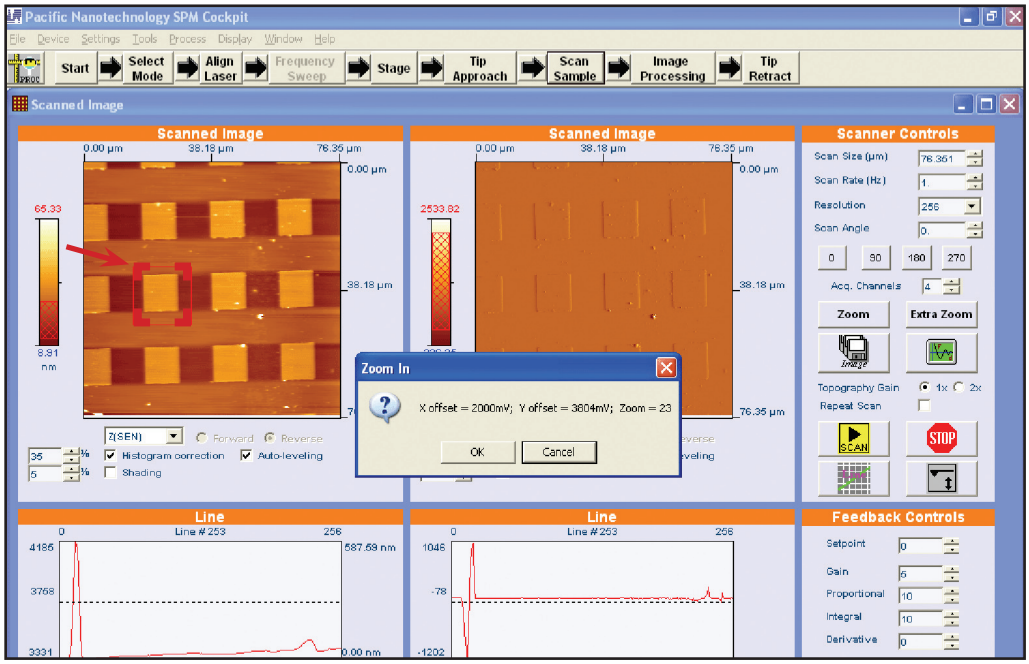


Figure 2.47: Zooming to a new scan region

  - Right-click OK to confirm the new scan region.

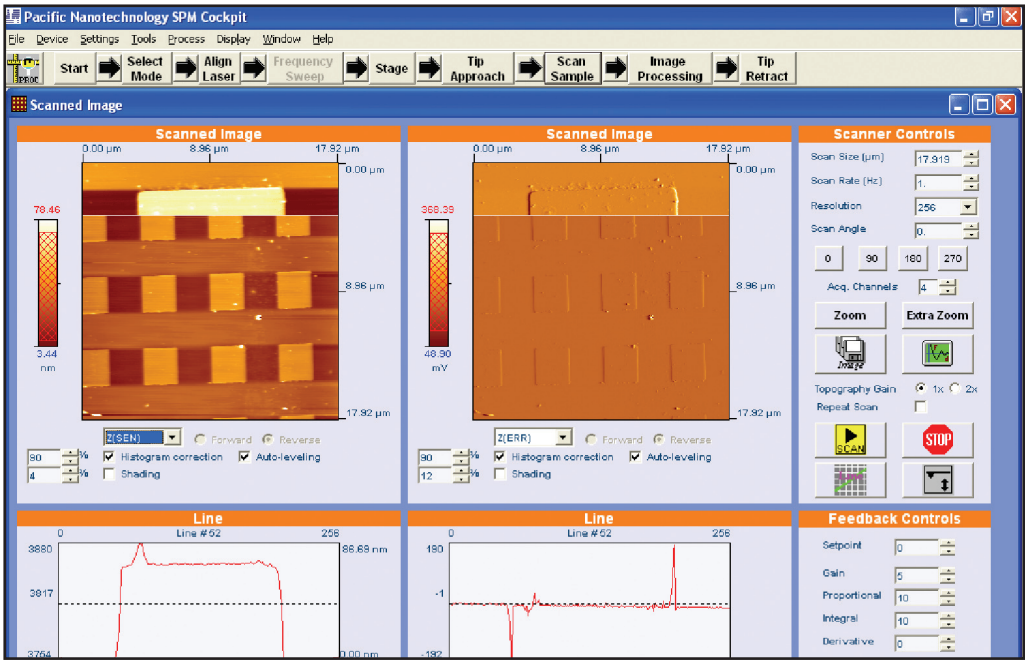


Figure 2.48: Confirming the new scan region

IMAGE PROCESSING

- Click Image Processing on the EZMode™ toolbar

Figure 2.49: EZMode™ Toolbar

- Click Select Source to open an image for processing

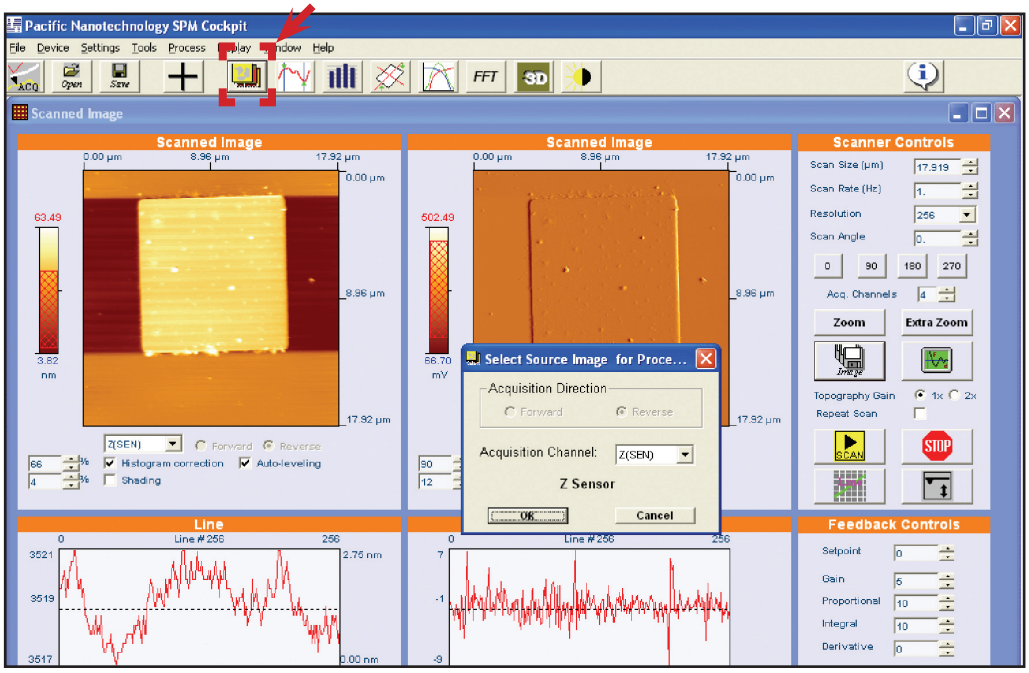
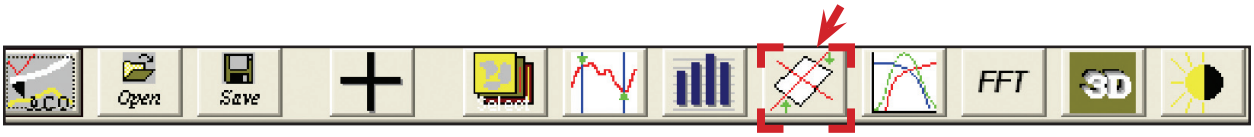


Figure 2.50: Image Processing Module

- Select the desired acquisition channel and direction for the image to be processed. The raw image data will not resemble the image in the scan image window, as some basic real-time image processing was applied as it was being acquired.

- Click to apply a plane correction.



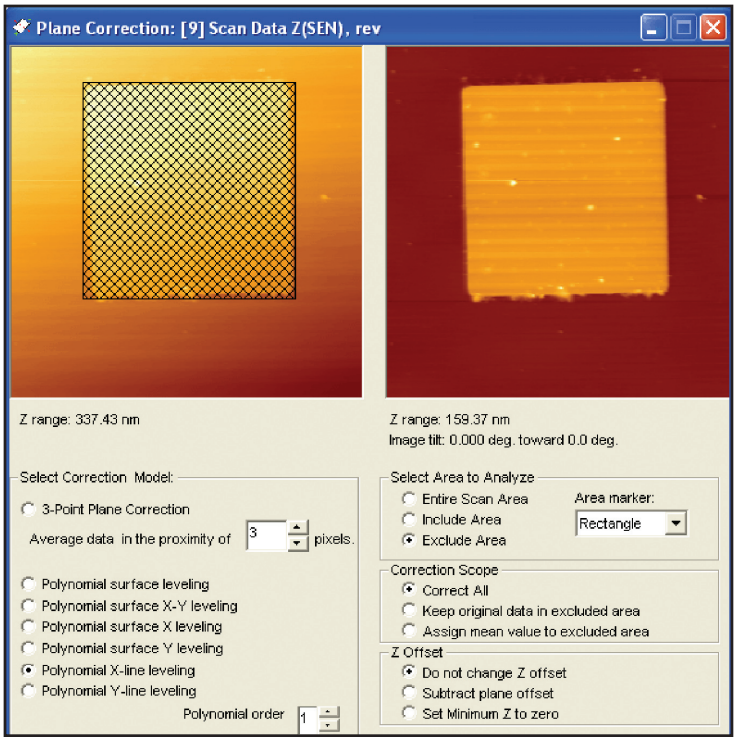
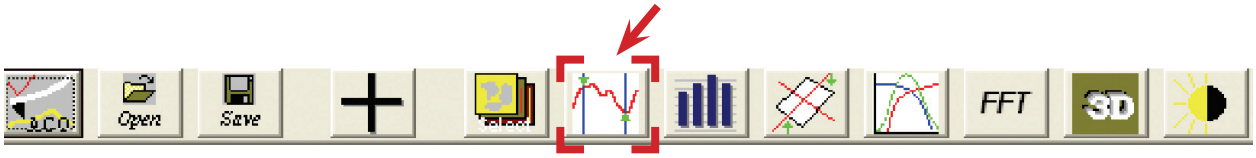


Figure 2.51: Plane Leveling Tool

- Under Select Correction Model, select:
  - Polynomial X-line leveling
  - Polynomial order: 1
- Under Select Area to Analyze, select:
  - Exclude Area
  - Area Marker: Rectangle
- To exclude the features on the PNI AFM reference, use the mouse to left click and drag in the image display so that every feature (both whole and partial) is completely covered.
- Click Apply and the leveled image appears in the right-hand display.

To do Line Profile measurements, select button as shown:



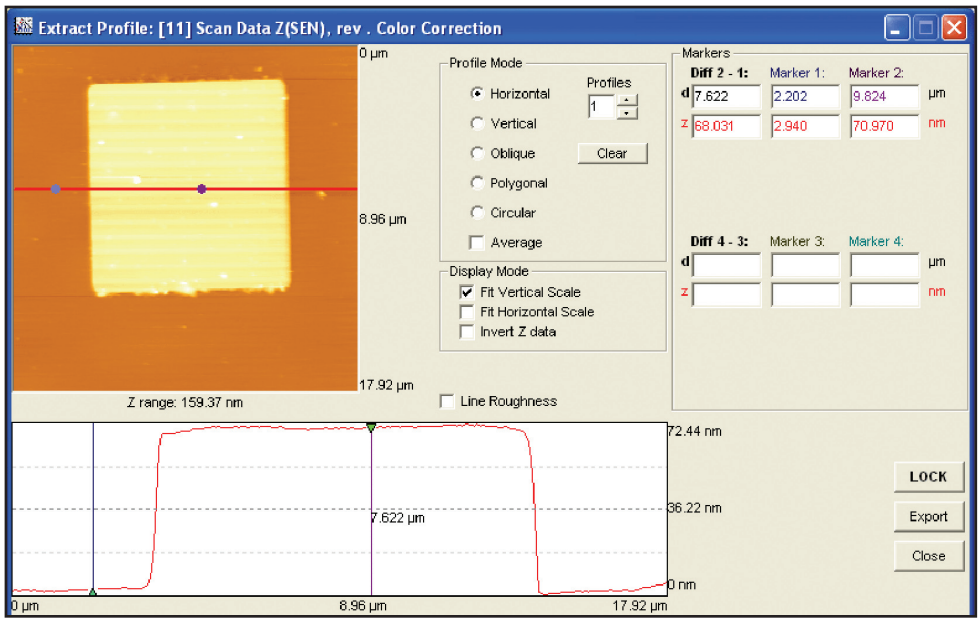


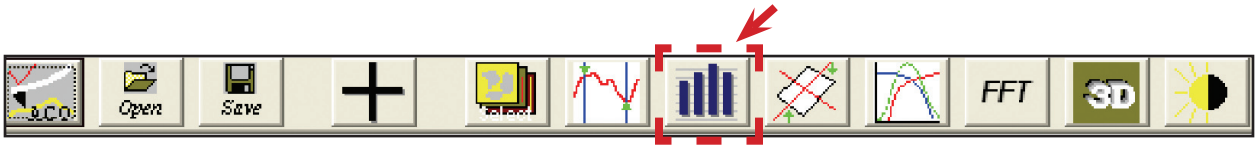
Figure 2.52: Line Profile Tool

- Under Profile Mode, select Horizontal.
- Under Display Mode: Check Fit Vertical Scale
- Left-click in the image display to select a line.
- Left-click in the line display to make measurement markers.

In the example above, measurements are made between the edges of two consecutive features on the PNI AFM reference. The measurements displayed to the right confirm a pitch of 20 ∝m and a Z-height of approximately 70 nm.

NOTE: These measurements should not be used to calibrate your instrument!

Select histogram tool and use the slider bars to mark the middle of the two ranges where the Z data points are clustered.



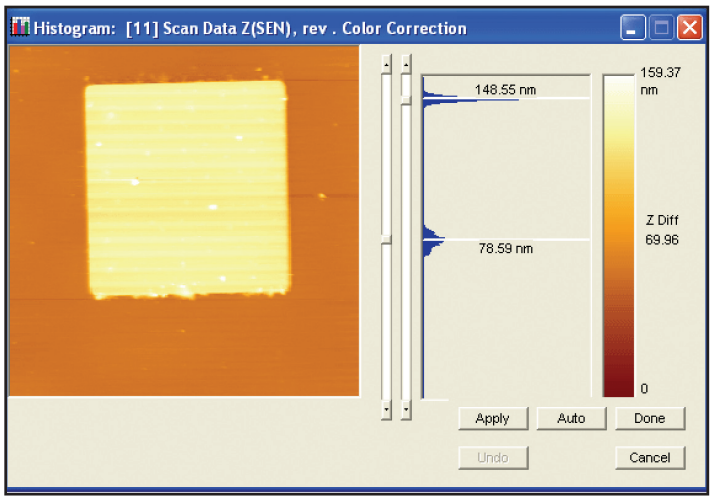
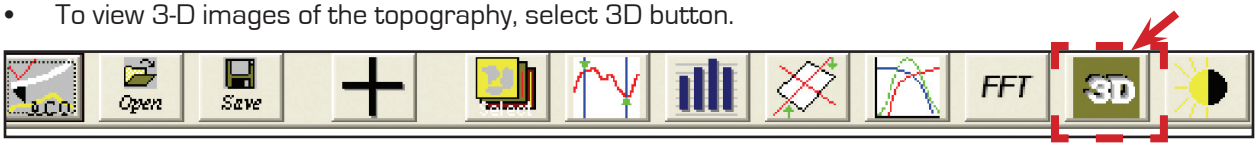


Figure 2.53: Histogram Tool

The Z Diff measurement on the vertical bar confirms the 70 nm height of the PNI AFM reference features.

- To save any of your processed images, select File / Save Image(s).
- To view 3-D images of the topography, select 3D button.



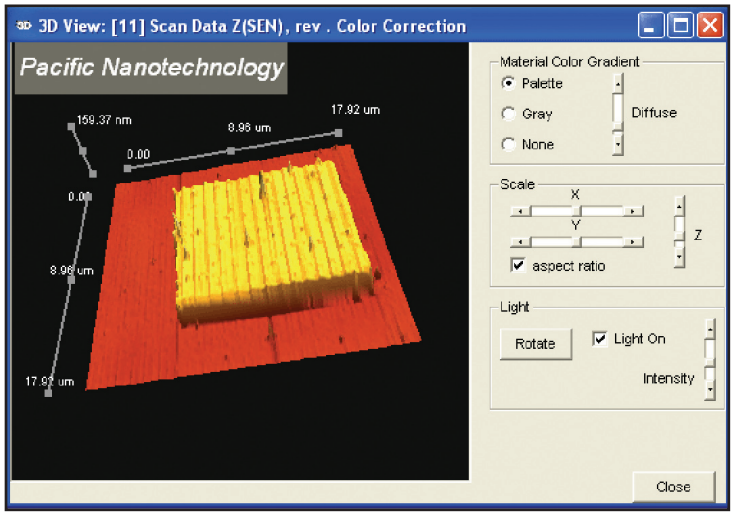


Figure 2.54: 3D View

CAUTION: To prevent damage to your scanner, probe, and sample, be sure to retract the tip before exiting SPM Cockpit™ software or turning off the Controller.

- Click Tip Retract

It is now safe to exit SPM Cockpit™ software.